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HEALTH IMPLICATIONS OF AIR POLLUTION

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PAPERS

HEALTH IMPLICATIONS OF AIR POLLUTION

By J. J. Bloomfield[1]

Synopsis

Although an old problem, air pollution has been the subject of increasing research because of the realization of its health implications. Studies have linked air pollution with loss of well-being or illness and have further shown that specific topographical and meteorological conditions may result in fatal concentrations of air-borne poisons. Reduction of the pollution load is not always economically feasible with available devices, but research and restriction should aid in the solution of the problem.

Industry as well as government must take steps to clean the atmosphere. The engineer in industry will play an important role in reducing the pollution load. On the governmental side, agencies already in existence have personnel which are qualified to assume responsiblity for this problem.

Introduction

The problem of atmospheric pollution is old, but the health implications have been the object of increasing scientific and lay concern throughout the United States. The first historical concern with air pollution was recorded as early as 1257, when Eleanor, the queen of Henry III of England, was reputed to have left the town of Nottingham because she was bothered by smoke. Legal cognizance of this nuisance came in 1306, when a royal proclamation was issued prohibiting the burning of coal in London. Following these early efforts to abate the smoke nuisance, England has conducted systematic studies[2,3,4,5,6,7,8,9,10,11] on atmospheric pollution since 1914.

Note.—Written comments are invited for publication; the last discussion should be submitted by December, 1951.

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[2] "Atmospheric Pollution in Leicester, A Scientific Survey," *Technical Paper No. 1*, Dept. of Scientific and Industrial Research, Atmospheric Pollution Research, His Majesty's Stationery Office, London, England, 1945.

[3] "Heat and Power Linkage," *Fuel Efficiency Bulletin No. 51*, Ministry of Fuel and Power, His Majesty's Stationery Office, London, England, August, 1948.

[4] A Report of the Joint Conference of the Institute of Fuel and the National Smoke Abatement Society, London, England.

Contemporary research in the United States has kept pace with that abroad. During the period from 1911 to 1914 the first study of all phases of the smoke problem was undertaken by the Mellon Institute of Pittsburgh, Pa.[12] Studies in Salt Lake City, Utah, and Grafton, West Va., followed in 1919. From 1926 to 1929, Baltimore, Md., Washington, D.C., Pittsburgh, New York, N.Y., Boston, Mass., Cleveland, Ohio, Columbus, Ohio, and other cities were the subject of investigations. Then, from 1931 through 1933, the United States Public Health Service (USPHS) undertook a survey of fourteen of the largest cities in the United States. The famous smoke-control program of St. Louis, Mo., in 1939 typified the smoke-abatement measures inaugurated in a number of other industrial cities.

Despite this early concern with air pollution, however, the full realization of the health implications inherent in the problem were not yet fully apparent. Understanding of the nature of air pollution has antedated this realization by less than a score of years. Only since about 1930 has it been possible to put the problem under a microscope to analyze its component parts. It is known that air pollution embodies more than the smoke aspect, which was recognized first, and consideration must also be given to the dusts, fumes, vapors, mists, and other contaminants that are emitted from industrial plants. The latter make up, by far, the more complicated phase of the problem because they do not lend themselves to a uniform solution.

The control of smoke is well understood. Smoke-abatement measures are based generally on the use of only nonvolatile or low volatile fuels or on the use of specially constructed furnaces that assure complete combustion. These smoke-abatement measures do not solve the entire polution problem, however. To rid the atmosphere of the contaminants spewed forth by countless industrial operations calls for a number of varied control methods. The spelters of zinc plants alone emit such particulate matter as zinc, lead, cadmium, sulfur, and chlorine, as well as gaseous substances like sulfur dioxide, carbon monoxide, and carbon dioxide. Considering the vast number of industries using raw materials and intermediate products, which produce great numbers of contaminants, as well as the millions of homes and transportation vehicles that contribute to air pollution, realization of the magnitude of the problem cannot be escaped.

Unless action is taken, an intensification of this problem can be expected. As new industries are developed, it is imperative that proper precautions be taken to control the resulting pollutants.

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[5] *Proceedings*, National Smoke Abatement Society, Chandos House, Buckingham Gate, London, England.

[6] "The Investigation of Atmospheric Pollution—A Report on Observations in the 5 Years Ended 31st March, 1944," His Majesty's Stationery Office, London, England, 1949.

[7] "The Weathering of Natural Building Stones," by R. J. Schaffer, *Building Research Special Report No. 18*, Dept. of Scientific and Industrial Research, His Majesty's Stationery Office, London, England, 1932.

[8] "The Smoke of Great Cities," by Shaw and Owens, Constable & Co., Ltd., London, England, 1925.

[9] "Smoke, a Study of Town Air," by Julius B. Cohen and Arthur G. Ruston, Edward Arnold & Co., London, England, 1925.

[10] "Smoke and Smoke Prevention," by Margaret Fishenden, *Encyclopaedia Britannica*, Vol. 20, 14th Ed., 1929, p. 839.

[11] "Dust," by S. Cyril Blacktin, Chapman & Hall, Ltd., London, England, 1934.

[12] *Bulletin Nos. 1–9*, Smoke Investigations by Mellon Institute of Industrial Research and School of Specific Industries, Univ. of Pittsburgh, Pittsburgh, Pa.

Anticipated increases in population also present difficulty, since people, as well as contaminants and certain meteorologic conditions, are factors of the air pollution problem. The congestion of population and concentration of industries are reflected in voluminous literature describing the economic and nuisance effects of air pollution. In addition to these considerations has come the awareness (and whether or not it is justified in every instance remains to be proved) that air pollution is affecting the people's sense of well-being. Air pollution has passed the nuisance stage and has more than economic and esthetic implications.

Effects of Air Pollution

Much speculation has been voiced over the effect of air pollution on the course of tuberculosis, its deleterious effect in shutting out the germicidal rays of the sun, and other theories; but the case does not rest on conjecture, speculation, and theory. The first major evidence of the health implication of air pollution came in 1930, when the Meuse Valley in Belgium was blanketed by a heavy smog and sixty persons lost their lives. Prolonged stable weather conditions had bottled up the contaminants in the valley for about four days, and the concentration of chemical fumes increased until it reached fatal proportions.

In October, 1948, similar meteorologic conditions were encountered in Donora, Pa., where almost 6,000 persons were affected, twenty of them fatally. In both instances, the affected communities, located in bowl-shaped valleys where contaminants could be easily confined, experienced a meteorological phenomenon known as an inversion. At such times, the temperature of the air at gound level is less than that of the air above, whereas, normally, the reverse is true. This stable condition minimizes the vertical mixing of the air that normally takes place, and the absence of strong wind currents keeps horizontal dispersion at a minimum. In Donora these conditions lasted four and one half days. Had they lasted only a few hours or a day or so, the results, of course, would have been different. Short periods of smog are not uncommon and present no danger of wholesale sickness or death. It is the prolonged smog that may have a disastrous aftermath.

Although the term "smog" originally meant a combination of smoke and fog, its connotation now includes all kinds of fumes, gases, and other emissions, in addition to particulate matter. The duration of a smog is dependent on meteorological conditions. Ordinarily, a wind or cleansing rain will come to sweep away the contaminants before they reach dangerous concentrations, but since weather can be "a bad actor," common sense dictates preparedness for any eventuality.

Aside from these dramatic, acute episodes, periodically recurring smogs with disagreeable effects occur in many areas. In Los Angeles, Calif., for instance, about ten to twenty times each year smogs cause residents to suffer severe lachrymation as well as irritation of the nasal passages. The Los Angeles situation affords one of the best examples of the distinction between smoke and industrial emissions in the etiology of air pollution. The City of

Los Angeles burns oil and gas and, therefore, has no smoke problem as such; yet it has a genuine air pollution problem.

More serious effects of contaminants on health may be illustrated by findings of investigations of plant-working environment, which can be more closely controlled than that of the general atmosphere. Lung disease has been shown to occur among employees exposed to beryllium compounds.[13,14,15] In some areas, it has been alleged that people living near beryllium plants have been affected. Investigations have also emphasized the occurrence of pneumonia in manganese plant areas.

To understand the health implications of air pollution, the Donora incident should be studied in more detail.[16] This was investigated for one year by the Industrial Hygiene Division of the USPHS. The salient points in the biological data are the incidence and severity of illness during the smog, the main clinical manifestations, and the significant relationships between the affection and other factors.

Forty-three percent of the population was affected, ranging from slight to extremely severe affection.[17] There were twenty fatalities. The affection was essentially an irritation of the respiratory tract and other exposed mucous membranes. Particularly noteworthy was the direct relationship of both incidence and severity with increasing age. This observation has much meaning because of increasing interest in the science of geriatrics and concern with any influences to which the elderly may be particularly susceptible. In searching for indications of pre-existing ailments it was considered highly significant that the fatalities had histories of previous cardiorespiratory disease.

The Problem of Air Pollution

Although these findings present a substantial body of data, they cast a long shadow of unanswered questions. The mass of accumulated data has succeeded in emphasizing just how few conclusions can be drawn. The acute health effects of air pollution have been verified, but no light has been shed on the long-range effects. The effects of acute exposure to concentrated contaminants under unusual meteorologic conditions are known, but the manner in which people's health is affected by continuous exposure to the usual concentrations under normal weather conditions year in and year out must be learned.

In addition to determining the chronic effects on healthy people, a special study must be made of the influence of air pollution on cardiacs, asthmatics, and people with other respiratory diseases. As yet, it is unknown whether air pollution only aggravates or also causes the onset of respiratory diseases.

[13] "The Toxicology of Beryllium," by F. Hyslop, E. D. Palmes, W. C. Alford, A. R. Monaco, and L. T. Fairhall, *Bulletin No. 181*, National Institute of Health, U. S. Govt. Printing Office, Washington, D. C., 1943.

[14] "Acute Pneumonitis and Pulmonary Granulomatosis of Beryllium Workers," by Willard Machle, Emil Beyer, Frederick Gregorius, *Occupational Medicine*, Vol. 5, 1948, pp. 671–683.

[15] "Delayed Chemical Pneumonitis Occurring in Workers Exposed to Beryllium Compounds," by Harriet L. Hardy and Irving R. Tabershaw, *Journal of Industrial Hygiene and Toxicology*, Baltimore, Md., September, 1946, pp. 197–211.

[16] "Air Pollution in Donora, Pa., Epidemiology of Unusual Smog Episode of October, 1948," *Public Health Bulletin No. 306*, U. S. Public Health Service, Washington, D. C., 1949.

[17] *Ibid.*, p. 23.

The effect of damage to the respiratory system on the cardiovascular system must also be evaluated. The possible special effects of air pollution on children and on elderly people must also be ascertained. Does the loss of sunlight lessen a child's resistance to disease? What is the effect on the aged? Science's conquest of communicable diseases has enabled people to live to more advanced years, and, since their life span has been increased, the effect of air pollution on this group must be considered to ensure that it is not a contributing factor to shortening their lives.

As one step toward answering all these questions, basic research is requisite to determine the concentration of substances necessary to produce either acute or chronic effects. It also must be learned whether the air contaminants from industry—gases, fumes, and particulate matter—always act singly on human beings, act in combination, or act on each other to produce an agent which is more poisonous than any of the single substances or than the total action in combination.

Values known as maximum allowable concentrations have been established for industrial environments where normal persons (excluding children and the aged) are exposed to in-plant contamination for 8 hours each working day. Comparable information is not available on contaminants in the outside atmosphere affecting individuals of all ages and in all physiological and pathological conditions over an uninterupted period, day and night.

Authorities who know the limitations must exercise care in encouraging air pollution ordinances. The smoke-abatement regulations in force in many cities, such as New York, are a step in the right direction, but legal standards for the control of other emissions cannot be developed until a more thorough study of the problem has been made. However, industry should take steps to correct their aspect of the situation, which, obviously, cannot be done overnight. Therefore, a pattern of action combining patience with vigilance, and, of course, a continuous program of research is indicated.

At the same time the engineer has the challenging task of finding new and more effective control methods. Although workable in most instances, available methods of control sometimes are either inadequate to perform the job of trapping contaminants, or they are too costly. To illustrate the economic impracticality encountered at times, it is conceivable that a small plant with a capital investment of $50,000 would be required, by an overstringent law, to spend more than its total assets to reduce atmospheric pollution with techniques in current use. Obviously, under such circumstances, a company would be forced to close its doors.

In the absence of suitable controls, plants may be required to move outside the city limits. This solution, of course, leaves much to be desired for general application. It might be the answer in limited instances if stricter and better city planning were encouraged, and if industrial zones were established in areas where the factor of air pollution has been given serious consideration. Until rigid zoning laws are enacted, a company moving to an isolated location cannot assume that it has complete freedom to pollute the atmosphere and that it, therefore, need not install proper control measures. All too frequently it has been demonstrated that domestic housing is built in the vicinity of a

plant. Then, regardless of the fact that the dwellings were the last to move to that site, the company is forced to take corrective steps by the pressure of public opinion. The wiser course of action would be for the company to install proper safeguards at the outset. In a true exercise of foresight in selecting a site for new operations, industry should give due consideration to the meteorologic conditions of a location as well as to transportation costs, availability of raw materials and personnel, and other factors.

Remedial Steps

By using available scientific techniques and apparatus, industry, housing, transportation, and other sources of contamination can reduce their air pollution load, despite the gaps in existing knowledge in this field. Air contamination can be readily evaluated by a combination of air sampling with specifically designed scientific equipment and subsequent laboratory analyses. This procedure is followed on a quantitative scale, enabling determination as to the concentrations of contaminants that may be present. The Donora study employed these techniques, and they will also be used in other surveys. As a result of the increasing interest in air pollution, new scientific methods and instruments are constantly being evolved. For instance, a "recorder" has been developed commercially for the continuous determination of sulfur compounds in the atmosphere. The electron microscope has facilitated the identification and classification of particulate matter. New recording instruments will determine the halogens and the chlorinated hydrocarbons in the atmosphere. In the laboratory, special equipment has been set up to indicate the reduction of ultraviolet rays and total sunlight when minute amounts of various contaminants are present in the atmosphere. Exposure chambers are being used to determine the effects of exposure to various concentrations of contaminants on human beings.

On the control side, in addition to smoke-control ordinances, emphasis must be placed on the need to control industrial emissions that do not lend themselves to that type of regulation. Here, too, various control techniques may be used effectively. The principle of dilution, using high smokestacks (some of which tower over 500 ft) may be adopted; or the answer may lie in conversion—as, for example, the complete combustion of gases to combat objectionable odors—or in collection. The latter technique utilizes a variety of principles and apparatus, such as ultrasonics, electrostatic precipitators, steam precipitators, scrubbers, mechanical filters, centrifugal separators, and gravity chambers. This variety of available measures ensures that, by and large, industrial emissions can be controlled, although better tools may have to be developed in certain instances.

To illustrate this point, the zinc plant in Donora (one of the chief contributors to the pollution load in that area) has already gone forward in the control of the operations that have been mainly responsible for contaminating the atmosphere. Furthermore, in order to be alerted to any impending adverse weather conditions in time to take further precautions, the company installed a teletype machine to receive daily reports of the United States Weather Bureau. All these actions will help to ensure that there is no repetition of the Donora crisis of 1948.

Courses of Action

There is a compelling urgency for further developmental and research activity because events have proved that air pollution is not a theory that can be shelved for a later, less busy day.

Since the intensive year-long investigation at Donora, the USPHS has been assisting the states on a consultative basis. Air pollution studies should be extended to give greater aid to the states with their problems. This activity should be in addition to, and of a different nature than, current smoke-abatement efforts, which must be continued.

In increasing numbers, industrial hygienists and sanitary engineers in state and local official agencies are concerning themselves with air pollution. Such specialists are the best qualified to assume this responsibility because control of atmospheric contaminants is only one step removed from their traditional function of controlling the working environment. By virtue of their position in health departments, they are also able to bring all the state's health resources to bear on this problem.

While official agencies are engaged in these studies, industry must work on similar projects simultaneously. There is an obligation on all industry to conduct diligent research into the status of its own problem. Each industry should study thoroughly its particular operations to determine what processes emit pollutants into the air as well as the nature and quantity of the contaminants. On this groundwork of data, industry can then base its research efforts to control the degree of pollution.

It must be realized that the operators of many plants began on such projects years ago, and they are to be highly commended. Others, however, are hiding behind the excuse that air pollution is either too vague or too overwhelming a problem.

Summary

Just as the people were shocked out of their apathy by the sad pollution of the waterways when that pollution reached such alarming proportions, so, too, they must realize that the time has come when industries can no longer spew contaminants into the air as a catch-all dilutant. One tragic example has already shown what may happen when weather conditions become unusual. Additional research may also discover insidious effects of everyday exposure to contaminants which may exact a toll on the vitality and well-being of the population. Although the extent of the problem is not known, the danger can be recognized.

The responsibility for the control of air pollution rests in large part with engineers, and the public will lean heavily on their efforts. No other problem confronting the engineering profession demands more ingenuity or the taxing of all resources to cope with than this responsibility for the health of the nation.

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